University of Regina | Faculty of Engineering and Applied Science

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Course name and number: ENSE 452

Instructor: Karim Naqvi

Assignment/Lab: Assignment #

Due date: Oct 24th

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On my honour as a future professional engineer and as a University of Regina student, I confirm this submission is my own work, and that I have not used any unauthorized material, devices, means, or information in writing this evaluation.

alok paranjape — **Signature**

Oct 24th — **Date**

1. **(10 marks)** Consider a system that has three tasks with periods: 10 millisecond, 39 millisecond, and 1 second. If the WCETs have been estimated at 4 milliseconds, 12 milliseconds, and 98 milliseconds, respectively, what is the total time-loading of the system? (We are ignoring context switch time)

   Is the task set guaranteed to have a feasible schedule, by the RMS criterion? If not, what would be the *easiest* rewrite that would make the three tasks schedulable? Explain your answer

Time loading:
(below)

Feasible schedule:
→ not harmonics, check if $U \leq n(2^{1/n} - 1)$
(1s is not a multiple of 39 ms)

$$U = \sum_{i=0}^{3} \frac{C_i}{P_i} = \frac{4\,ms}{10\,ms} + \frac{12\,ms}{39\,ms} + \frac{98\,ms}{1000\,ms}$$
$$= 0.80567 \rightarrow 80.57\%$$

$$n(2^{1/n} - 1) \rightarrow 3(2^{1/3} - 1) = 0.77976$$
$$\rightarrow 77.98\%$$

→ since 80.57% is not ≤ 77.98%
it's not feasible for RMS

The easiest rewrite:

Giving the 2nd task a 40 ms period (or something divisible by 10)
then it would be a harmonic set,

and could get a feasible schedule, even with that Utilization value

2. **(20 marks)** A preemptive system has three concurrent tasks, described by the table below (context switch time is ignored). The background, or idle task is assumed to be nonessential and is fully preemptable by all higher priority tasks.

no task numbers

Task	Cycle	Execution Time	Priority
TaskA	10ms	4ms	3 (highest)
TaskB	20ms	5ms	1
TaskC	40ms	10ms	2
Idle	(continuous)	5ms	—

(a) Answer the following:

i. What is the system utilization?

ii. Is this task set RMS scheduled?

iii. What is the response time for each task?

iv. Do all the tasks meet their deadlines? By how much does each task beat, or miss, its deadline.

a) (ignoring the continuous task, since i) there's no cycle given)

$$U = \sum_{i=0}^{3} \frac{C_i}{P_i} = \frac{4ms}{10ms} + \frac{5ms}{20ms} + \frac{10ms}{40ms} = 0.9$$

$$= 90\% \text{ of the CPU}$$

ii) Yes, since the task set is harmonic (10, 20, 40 are multiples)

iii) finding Reaction times:

	P_i	C_i	priority
A	10	4	3 (highest)
C	40	10	2
B	20	5	1 (lowest)

Finding R_A: guess $R_A^0 = 0ms$

$$R_A^{1+0} = C_A + \sum_{\forall j \in hpt\} \left\lceil \frac{R_A^0}{P_j} \right\rceil \cdot C_j = 4 + \frac{0}{P_j} C_j$$

($\forall j \in hpt\}$: higher priority; P_j and C_j are empty here)

$= 4ms$

$$R_A^2 = C_A + \sum_{j=\{\}} \lceil w \rceil = 4ms + 0 = 4ms$$

converged

$R_A = 4ms$

Find R_C: Guess $R_C^0 = 0ms$

$$R_C^1 = C_C + \sum_{j \in \{A\}} \left\lceil \frac{R_B^0}{P_j} \right\rceil C_j = 10 + \frac{0}{10} \cdot 4 = 10$$

(only A has higher priority)

$$R_C^2 = 10 + \frac{10}{10} \cdot 4 = 14$$

$$R_C^3 = 10 + \frac{14}{10} \cdot 4 = 15.6$$

$$R_C^4 = 10 + \frac{15.6}{10} \cdot 4 = 16.24$$

$$R_C^5 = 10 + \frac{16.24}{10} \cdot 4 = 16.496$$

$$R_C^6 = 10 + \frac{16.496}{10} \cdot 4 = 16.5984$$

$$\vdots$$

$$R_C^{10} = 16.666229\,76$$

assume it converges at like 16.666 ms

$$R_C = \underline{16.666 \text{ ms}}$$

Find R_B

Guess $R_B^0 = 0$ ms

$$R_B^1 = C_B + \sum_{j \in hp\{A,C\}} \left\lceil \frac{R_B^0}{P_j} \right\rceil C_j = 5 + \frac{0}{10} \cdot 4 + \frac{0}{40} \cdot 10 = 5 \text{ ms}$$

A and C have higher priority

$$R_B^2 = 5 + \frac{5}{10} \cdot 4 + \frac{5}{40} \cdot 10 = 8.25$$

$$R_B^3 = 5 + \frac{8.25}{10} \cdot 4 + \frac{8.25}{40} \cdot 10 = 10.3625$$

$$R_B^4 = 11.7356\,25, \quad R_B^5 = 12.628156$$

$$\ldots\ldots R_B^{17} = 14.27958 \Rightarrow \text{converging at}$$

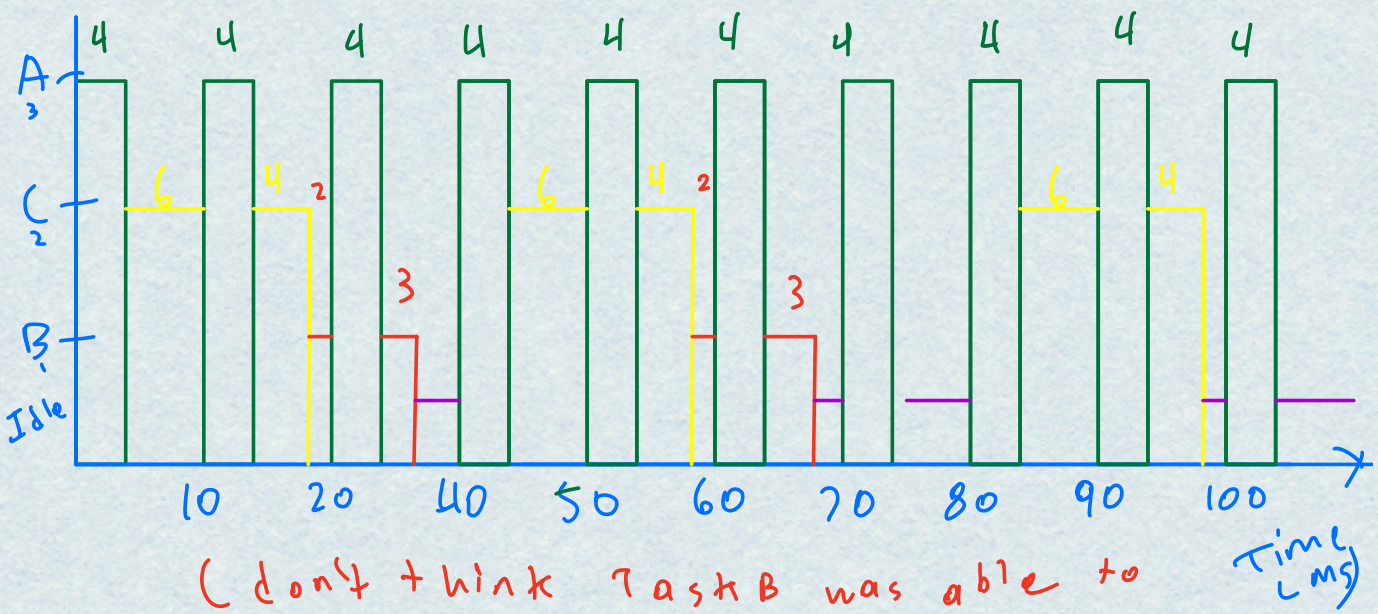
$$\underline{R_B = 14.28 \text{ ms}}$$

iv) Assuming meeting a deadline is comparing cycle w/ response time, all three meet their deadlines, by

Task A: 10 - 4 → 6 ms
Task B: 20 - 14.28 → 5.72 ms
Task C: 40 - 16.666 → 23.334 ms

iv)

priority



(don't think Task B was able to

start every 20ms as expected?)

(b) Now suppose the priorities of Task B and C are interchanged, that is, TaskB has priority 2 and TaskC has priority 1. Answer the following:

i. What is the system utilization?

ii. What is the response time for each task?

iii. Do all the tasks meet their deadlines? By how much does each task beat, or miss, its deadline.

iv. Draw an execution time line for this system.

no task numbers?

b)

i) same as before:

$$U = \sum_{i=0}^{3} \frac{C_i}{P_i} = \frac{4ms}{10ms} + \frac{5ms}{20ms} + \frac{10ms}{40ms} = 0.9$$

$= 90\%$ of the CPU (still)

ii)

R_A: still the same: $R_A = 4ms$

	P_i	C_i	priority
A	(10,	4)	3 (highest)
B	(20,	5)	2
C	(40,	10)	1 (lowest)

Finding R_B

$$R_B^0 = 0\ ms$$

$$R_B^1 = C_B + \sum_{j \in hpB3} \left\lceil \frac{R_B^0}{P_j} \right\rceil C_j = 5 + \frac{0}{10} \cdot 4 = 5\ ms$$

$$R_B^2 = 5 + \frac{5}{10} \cdot 4 = 7\ ms$$

$$R_B^3 = 5 + \frac{7}{10} \cdot 4 = 7.8\ ms$$

$R_B^4 = 5 + \frac{7.8}{10} \cdot 4 = 8.12\,ms$

$\vdots$

$R_B^{10} = 8.333298\ldots \rightarrow$ converges at $R_B = 8.33ms$

Find R_C: assume $R_C^0 = 0ms$

$$R_C^1 = C_C + \sum_{\forall j \in \{A,B\}} \left\lceil \frac{R_C^0}{P_j} \right\rceil C_j =$$

$$= 10 + \frac{0}{10} \cdot 4 + \frac{0}{20} \cdot 5 = 10\,ms$$

$$R_C^2 = 10 + \frac{10}{10} \cdot 4 + \frac{10}{20} \cdot 5 = 16.5\,ms$$

$$R_C^3 = 10 + \frac{16.5}{10} \cdot 4 + \frac{16.5}{20} \cdot 5 = 20.725\,ms$$

$\vdots$

$R_C^{12} = 28.55257\,ms \rightarrow$ converges at $R_C = 28.553\,ms$

$R_A = 4\,ms$

$R_B = 8.33ms$

$R_C = 28.553\,ms$

iii) Like before, they all make it

10 - 4 = 6 ms

20 - 8.33 = 11.67 ms

40 - 28.533 = 11.447 ms

iv)